DOCUMENT RESUME

ED 417 954 SE 061 261

AUTHOR Pushkin, David B.; Colon-Gonzalez, Maria H.
TITLE Access to Knowledge and Critical Thinking in General Chemistry via Social Constructivism: Pedagogical and Curricular Opportunities for Minority Science Majors.
PUB DATE 1998-04-00
NOTE 46p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 13-17, 1998). Some pages printed in color may not reproduce well.
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Academic Achievement; *Chemistry; *Cognitive Processes; *Constructivism (Learning); Cultural Influences; Educational Strategies; Epistemology; Equal Education; Higher Education; *Minority Groups; Science Curriculum; Thinking Skills; Undergraduate Study

ABSTRACT

This research study examines the nature of socio-cognitive influences on general chemistry students' learning and success. In this study, "learning" means gaining critical thinking skills and "success" means good academic grades. From a social constructivist and postmodern perspective, learning and success are considered functions of enculturation and empowerment and are measured through a variety of quantitative and qualitative means. The epistemological basis for the study includes principles such as access to knowledge, pedagogical content knowledge, postmodernism, social constructivism, and critical thinking. A discussion of epistemological racism, institutionalized racism, and the context of gender is also included as background to the study. Contains 66 references. (DDR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 417 954

Access to Knowledge and Critical Thinking in General Chemistry via Social Constructivism: Pedagogical and Curricular Opportunities for Minority Science Majors

David B. Pushkin, Ph.D.
AERA Member # 0103380-980430
Montclair State University, Department of Chemistry and Biochemistry
Upper Montclair, New Jersey USA 07043
(973) 655-7118; pushkin@pegasus.montclair.edu

María H. Colón-González[1]
Montclair State University, Health Careers Program
Upper Montclair, New Jersey USA 07043
(973) 655-7069; colonmh@saturn.montclair.edu

Paper Presentation at the 1998 AERA Annual Meeting in San Diego, CA.
April 13-17
Special Interest Group: Education in Science and Technology

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
D. Pushkin
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

[1] Currently Human Resources Advisor for Nortel CALA, Inc. in Fort Lauderdale, Florida.

BEST COPY AVAILABLE

ABSTRACT

Science, at the university level, is notoriously presented from the perspective of a "conformist apprenticeship." This perspective alienates and excludes, not does not nurture and include. The paradigm of tradition and conformity dictates "whiteness" and "masculinity" are prerequisites for successful scientists; anything less is considered a personality weakness and intellectual deficiency. To sacrifice one's gender, ethnic, and cultural identity -- the vehicle for conformity -- is to lose oneself as a human individual. Science is no longer seen as part of a person's being; it is seen as a fundamental identity, a metaphorical genetic code.

Some science faculty are cognizant and sensitive to the contextual nature of knowledge, learners, and learning. Low esteem, expectations, and sensitivity towards students clearly reflects an epistemological racism (or discrimination at the least). Eventually this leads to the institutionalization of this level of racism, perpetuating generations of inequity in the education setting. Inequity in this case is not necessarily a function of numbers; it is a function opportunities based on a "level playing field."

This current study examines the nature of socio-cognitive influences on General Chemistry students' learning and success. By learning, we mean critical thinking skills; by success, we mean academic grades. From a social constructivist and postmodern perspective, learning and success are a function of enculturation and empowerment. A variety of quantitative and qualitative measures determine the extent of learning and success. However, at this stage, it is unclear how much learning and success is achieved. Long-term results will ultimately depend on student maturation processes and entrenched faculty beliefs.

INTRODUCTION

Montclair State University (MSU) is a teaching university, serving approximately 13,000 undergraduate and graduate students, located 12 miles west of Manhattan with a significant African-American and Latino-American population. The relative proportion of female and ethnic minority students majoring in Biology, Chemistry, or Biochemistry is considerably higher than the university-wide average in other departments; a significant academic influence for this exists within the College of Science and Mathematics (CSAM).

This current academic year, a faculty member from the Department of Chemistry and Biochemistry (DC&B) collaborates with the Director and Staff of the Health Careers Program (HCP) in a challenging undertaking. Our primary goals are: (1) improve retention rates among science majors of African or Latino heritage, (2) empower these students with the academic credentials necessary for professional or graduate school, and (3) promote a learning culture that emphasizes critical thinking and life-long learning.

We focus our attention on the first two years of chemistry courses for Chemistry, Biochemistry, and Biology majors: CHEM 120-121 (General Chemistry I and II), CHEM 230-231 (Organic Chemistry I and II), and CHEM 232-233 (Organic Chemistry Lab I and II). These are rigorous courses with increasingly restrictive pre-requisites. Each semester, the DC&B offers at least 8 sections of CHEM 120 or CHEM 121, 2 'double' sections of CHEM 230 or CHEM 231, and 4 sections of CHEM 232 or CHEM 233. Relatively small class sizes are desirable. General Chemistry lab sections are limited to 28 students; two sections are pooled together for a common 'double' lecture section. The same format applies for Organic Chemistry, where lab sections are limited to 24 students.

There exist, unfortunately, a number of constraining factors. First, HCP students have not experienced the same level of pre-college opportunities for academic and professional success as other students. Second, retention as majors rates, graduation rates, and post-graduate matriculation rates are not as high as expected or desired. Third, DC&B faculty generally believe in a traditional curriculum prescribed by the American Chemical Society, traditional teaching methods, and the assumption that chemistry enrollments are homogeneous in ability.

For example, all CHEM 120 students are assumed to have had a 'legitimate' year of high school Chemistry experience. All CHEM 121 students are assumed to have successfully passed CHEM 120. All Organic Chemistry students are assumed to have

successfully passed CHEM 120 and CHEM 121. The reality of heterogeneity versus the assumptions of homogeneity clash; students ultimately become the perpetual casualties.

The limited opportunities by HCP students may be a function of previous academic experiences, personal experiences, home culture, and current faculty attitudes. Our undertaking seeks to bridge these opportunity and achievement inequities by a number of steps. First, HCP students matriculate to MSU during the summer, so they can participate in six-week summer enhancement courses to strengthen foundations in chemistry and mathematics. Similar enhancement courses are available for second-year students, especially in organic chemistry.

Second, HCP students participate in a new six-week course added to the experience, a Critical Thinking and Problem Solving Workshop. This workshop meets weekly for two hours, where first-year students explore the meaning of critical thinking, problem solving, and applications to introductory chemistry and physics concepts. Students work in cooperative groups on problem sets; multiple forms of assessment are used by the instructor.

Third, HCP students are constantly reminded of the opportunities available to them and the expectations of the program. From the very beginning, the enculturation process takes place, where students are challenged to be responsible and independent thinkers, establish personal goals, and become more aware of themselves on a college campus. Students are challenged to be active learners, not passive recipients of knowledge. Most importantly, students are challenged not to take things for granted. Admission to MSU does not guarantee the future; the effort by students ultimately determines the future.

THEORETICAL FRAMEWORK

The epistemological basis for this undertaking includes the following principles: (1) Access to Knowledge, (2) Pedagogical Content Knowledge (PCK), (3) Postmodernism, (4) Social Constructivism, and (5) Critical Thinking. Our undertaking primarily focuses on the socio-cognitive influences affecting HCP student learning and success.

Access to Knowledge

When educators consider gender, culture, race, and ethnicity irrelevant factors in making pedagogical and curricular decisions, they instead find relevance to explain the 'shortcomings' of students. Low esteem, expectations, and sensitivity towards students clearly reflects an *epistemological racism*. This eventually leads to *institutionalized racism*, perpetuating generations of inequity in the education setting. Institutional racism is an action; epistemological racism is a theoretical framework (Scheurich and Young, 1997).

HCP students know this all-too-well; they come from a learning culture based on the assumption of "they can't do it." When a learning culture works from this assumption, learning experiences become meaningless, if not inadequate. Students graduate with little awareness of themselves, what they were taught, or what they learned. Schooling, to this point, was a matter of passing time and moving along, a perception that no investment was made, since there was no vested interest.

The Context of Gender:

A commentary by Christine Wennerås and Agnes Wold (1997) compared applicants for postdoctoral fellowships in Sweden. Women consistently received lower rating scores than men for scientific competence, proposed methodology, and relevance of their research proposal. Even if these women had an equal number of publications, their rating scores were lower, as women typically published in more general journals. Men published in more specialized journals, which carried more weight with peer reviewers. Expertise was perceived an indirect function of gender.

However, a most intriguing assertion was that women applicants conducted less challenging research, thus had inferior training compared to men, adding to the perception of expertise. The reason? Many of these women were not affiliated with a prestigious research group; the quality of their work was questioned. Their graduate

training was a double-edged sword. They were unwelcome by prestigious research groups for being women, and further punished for not being the product of a prestigious research group (Pushkin, 1997a). If we are not affiliated with the most-recognized departments, are we doomed to be irrelevant?

Upon entering the university, students of a perceived inferior learning culture confront new problems. Because of their previous backgrounds, faculty either seek to cater to an encultured ignorance, or punish it. Empowerment to overcome such ignorance is inadequately fostered, if not addressed.

> Clearly there are a numberof institutions which play a part in the reproduction of inequality, whether at a material or an ideological level. The family and the media, it can be argued, both work at an ideological level in perpetuating inequality of the sexes, while firms which pay lower wages to female workers operate at a material level. However, the institution which many sociologists have regarded as central in perpetuating inequality -- and also, crucially, central in potentially *eliminating* inequality -- is education. From the nineteenth-century reformers who pressed for universal school to today's schemes for increasing the numberof girls studying science, education has been the site of the struggle for equality of opportunity. (Thomas, 1990, p. 2)

As Kim Thomas (1990) shares with us, everything inevitably comes back to education, teaching, and learning. What is the culture of classrooms, schools, colleges, and universities? What are the pre-existing affective and cognitive models males and females bring to the culture? She points out the emphasis researchers place on gender is not related to increasing the number of educational opportunities for women; the choices women make with their opportunities demand more attention. What are the areas women decide to study? Why? What are the internal and external influences for these decisions? Is it merely a coincidence too few women are in physics, and too many are in the language arts? Thomas (1990) is among many who doubt this, primarily because inadequate research has been done on gender issues in higher education.

For example, many physicists believe a 'gender situation' no longer exists, primarily because women account for more than half the enrollment in introductory physics courses. However, this observation is misleading, as many physics departments remain all-male in terms of tenure-track faculty (Pushkin, 1997b, 1998a). Thomas (1990) asks three pertinent questions:

(1) What are the educational processes which currently result in fewer women studying science than men?

(2) Why is specialization in other areas regarded as indicative of 'failure'?

(3) Would an increase in the number of women choosing to study physical science and engineering result in greater equality for women? (p. 4)

> Equity is not merely a matter of educating equal numbers of boys and girls or appropriate proportions of majority and minority students to a specific level of competence, in this case, in mathematics and science. Rather, it includes equity in access (who studies technical subjects); equity in education (who has the curricula, materials, and instruction for optimal education); equity in resources (who has optimal and equal facilities and other types of support); and equity in leadership (who has access to and success in a myriad of leadership roles). (Kahle, 1996, pp. 57-58)

The Context of Ethnicity:

Jane Butler Kahle (1996) notes among ethnic minorities, African-American girls are most likely to get teacher attention and support in elementary level science and math classes; this sharply declines, however, as girls progress through middle and high school. Beatriz Chu Clewell and Angela Ginorio (1996) further note African-American women seem more sensitive than male counterparts to race as a factor in their treatment by faculty, students, and colleagues. Although these women had difficulty distinguishing between racist and sexist behaviors, this only reinforced a larger issue: ethnic minorities of both genders felt uncomfortable and unwelcome in science classrooms.

Teresa Greenfield (1996) notes when educational studies provide data on ethnicity, the category 'Asian' is quite misleading. Although Asian-Americans are considered well-represented and successful in science, a great disparity among Asian ethnic groups exists. While Japanese, Chinese, and Korean-American students may indeed represent Asian success, Filipino-American and native Hawaiian students lag considerably behind.

A potential reason for such data, according to Mary Atwater (1996), is that science education research is predominantly done by "White researchers;" few science education researchers are "people of color." Consequently, according to James Scheurich and Michelle Young (1997), biased perspectives yield biased analyses of data.

Epistemological racism, they suggest, is the manifestation of researchers lacking the experience and perspective to race-oriented issues; researchers' arguments can be irrelevant, simply because they never really understand the true nature of what they argue.

> For example, a superintendent may consciously not promote a Hispanic-American to the principalship in a majority White geographical area even though the Hispanic-American applicant may be the most qualified. While this superintendent may be consciously acting in a racist manner, she or he will publicly provide a socially acceptable reason for her or his decision. Persons making covert, racially biased decisions do not explicitly broadcast their intentions; instead, they veil them or provide reasons that society will find more palatable.
>
> Institutional racism exists when institutions or organizations, including educational ones, have standard operating procedures (intended or unintended) that hurt members of one or more races in relation to members of the dominant race. Institutional racism also exists when institutional or organizational cultures, rules, habits, or symbols have the same biasing effect. For example, if an institution's procedures or culture favor Whites for promotion, such as promotion to full professorship or to a principalship, over persons of color, this is institutional racism. (Scheurich and Young, 1997, p. 5)

When educators use the labels "culturally disadvantaged," or "cultural deprivation" to explain the lack of success some minorities enjoy at universities, Scheurich and Young (1997) also consider this institutional racism. These labels suggest minority students have intrinsic 'defects' precluding them from enjoying the same success as White students under the same conditions. Low expectations and intellectual exclusion of minorities, the most blatant forms of institutional racism, are not manifestations of epistemological racism.

Atwater argues 'culture-free' science is disastrous (Atwater, Crockett, and Freeman, 1997). Culture, she argues, is essential for social groups to survive and adapt to various environments and systems. Educators and education researchers who are insensitive to the significance of culture, fail to recognize the essence of those teaching and learning science. Some inexperienced educators have preconceptions about cultural and ethnic minorities in terms of behavior and intellectual ability; others preconceptions are in terms of academic and professional motivation.

In their study, Atwater, Crockett, and Freeman (1997) interviewed a female teacher education major who saw no reason to change her teaching methods for minority students; she believed science should be taught the same way, regardless of students' "social or economic class." They also interviewed a male teacher education major who identified 'culture' as something from different countries; as long as one lived in the United States, everyone was an American. He also considered 'minority' and 'ethnicity' equivalent terms, primarily because he felt all ethnic groups had "handicapping conditions," no different than a physical disability.

Each student teacher spoke in terms indicative of epistemological racism. Unfortunately, as these prospective teachers become part of the education establishment, they potentially have the power to institutionalize their level of racism, perpetuating generations of inequity in the education setting.

Will these be the teachers who perpetuate the practice of tracking in our schools? What will be their criteria for tracking in science? Will Black and Hispanic students be shooed away from the physical sciences so early in their education, any intervention might be too late (Pushkin, 1994a)? Will they be continuously held back in math and language arts classes, precluding them from having the prerequisite tools to succeed in science? How will educators enable these students to have opportunities while playing 'catch-up'? Are these students predisposed for denial of opportunities, because of a detached organization of decision makers and their limited perspectives (Macedo, 1994)? Are these teachers willing to even address the contexts of race, ethnicity, and opportunity (Delpit, 1988)?

The Context of School Culture:

> Unitary / sameness in differences is illustrated, as well, in the concept of *voice*. Differences are invoked hermeneutically to make sense of a group's distinctive cultural content -- the *voice* of students, African Americans, Latinas / os, women, and so on. The political struggle of the teacher is thus to make the different voices into legitimate elements in the construction of pedagogy -- particularly those of groups that have been socially and economically marginalized. But the concept of *voice* maintains the very rules of "sameness / difference" that it seeks to violate. The idea of *voice* integrates structural notions about groups omitted from public participation with a phenomenological assumption that different groups' experiences are 'natural" and "real" only to them. (Popkewitz, 1998, p. 25)

Is exclusion simply a matter of pragmatism within the science and educational establishments, or is there an underlying ideology in charge? A manifestation of what bell hooks refers to as the "White supremacist capitalist patriarchy" (hooks, 1994)? Perhaps the sports journalist Ralph Wiley was right; Blacks are held to a higher, more pressurized standard for success than Whites (Wiley, 1991). Although many corners of society have low expectations of minorities, the bar for ultimate success is perhaps raised higher, to ensure failure and maintain arbitrarily choreographed demographics. This can very well be the case for women, African-Americans, Hispanic-Americans, Native Americans, and some Asian-Americans (Pushkin, 1997a). Does one need to lose his/her identity to achieve success and opportunities (Cochran-Smith, 1995)? Is access to knowledge part of larger battle for cultural power (Giroux, 1988)?

> Long before the word "multiculturalism" became fashionable, [Dr. Martin Luther King, Jr.] encouraged us to "develop a world perspective." Yet, what we are witnessing today in our everyday life is not an eagerness on the part of neighbors and strangers to develop a world perspective but a return to narrow nationalism, isolationism, and xenophobia. These shifts are usually explained in New Right and neoconservative terms as attempts to bring order to the chaos, to return to an (idealized) past. (hooks, 1994, p. 28)

Why are minorities advised to major in "less challenging" disciplines? Are universities more interested in guaranteed graduation rates than meaningful learning and growth experiences? Why did Paulo Freire promote reading literacy for the Brazilian people? He knew opportunity depended on empowerment (Freire, 1970); without basic human power, people are excluded from societal process and denied opportunities within society. Perhaps we observe academic practices of *perpetuation of the species* and *survival of the fittest*. What do these Darwinist philosophies mean in our schools?

Many science departments appear to believe that the primary purpose for their existence is to produce majors (Pushkin, 1994b, 1997c). University faculty are growing old; replacements will be needed someday. Where will those replacements come from? The science majors they teach! After all, who better to replace them than their academic offspring, their clones? Hence, a *perpetuation of the species*.

What is the *survival of the fittest* philosophy? The debate endures whether education should be a pump or a filter. Should we be pumping well-rounded learners into a democratic society, or should we be filtering the weaklings from the desired pool of future technicians and technocrats? Do introductory science courses need to be "weed-out" courses? Do we reserve only the best science education for those most suited for a career in science, or do we educate the entire population (Babcock, 1996; Hobson, 1996a,b; Hoogstraten, 1996; Pushkin, 1996)?

All members of a democratic society deserve a level playing field, where everyone has a common foundation of knowledge; science cannot afford to flame the fires of inequity between the *haves* and *have nots*. Having expertise in science is one thing; having a monopoly on knowledge is another.

This is essentially an issue of epistemology. Maintaining aristocratic views of teaching and learning, the species will be perpetuated, only the fittest will survive, inequity will continue, and reform will be meaningless. Why do we teach? What do we teach? How do we teach it? To whom do we teach it to? Teaching, learning, and the curriculum are NOT mutually exclusive.

Pedagogical Content Knowledge (PCK)

Effective teachers, according to Lee Shulman (1986), require four types of knowledge: (1) knowledge of content, (2) knowledge of pedagogy, (3) knowledge of learning processes, and (4) knowledge of the learning environment. The composite of these knowledges is known as PCK; classroom educators need strength in all four types of knowledge.

It is simply not enough to be an expert in chemistry to be a chemistry educator. Such educators need to know when certain pedagogical approaches are more appropriate than others, how certain students' learning processes are enhanced or hurt, and what constraints exist within their school culture. If a chemistry educator is a strong proponent of fostering critical thinking, but teaches in a department that only seeks minimal competency, that educator will fail.

However, that failure is from the perspective of the school culture. What may be successful and empowering for students, may be unwelcome and criticized. A school, and its population, encultured to low expectations will punish nurturing and challenging pedagogical practices. That punishment could come in the form of censorship by peers, declining student enrollment, or poor evaluations by peers and students alike.

It takes strong and committed educators to battle such entrenched beliefs and practices, and bring about cultural change. Teachers' PCK ultimately must be a function of their epistemologies. Some teachers dispense content; others educate people. Teachers cannot simply become proficient in pedagogy without any underlying beliefs. PCK is the manifestation of a teacher's broadened perspective. The more narrow the perspective, the less effective the teacher. Regardless of a teacher's peer culture, professional malleability does a disservice to the classroom culture and students.

Postmodernism

In the postmodern view, science, as for any process or body of knowledge, is neither arbitrary nor absolute; it is constructed within a socio-political hierarchy of status and power. Educators and learners alike are active participants in the teaching and learning process, where knowledge is to be examined critically, debated, deconstructed, and reconstructed. Knowledge cannot simply be dispensed for students to blindly accept and regurgitate. Teaching and learning is a process of dialog, mutual respect, and mutual cognitive growth; the process is one of interaction within a community of learners.

Obedience still seems a highly valued commodity in education. Students are still taught work skills (Giroux, 1992), be they college-bound or not; cultural capital, homogeneity, and the curriculum are not always distinguishable (Greene, 1992; Pinar, 1992). One must wonder if "critical thinking" is disseminated to students as "thinking to avoid criticism." To be "good" is still a social norm in our schools (Lewis, 1992); students who embrace the great tradition will know of success and rewards (Kincheloe, 1992).

Noted author Sheila Tobias coins the term "obedience quotient (OQ);" for a student to indicate successful learning, one is forced to answer in the expected manner. This is hardly a celebration of individuality or creativity; what is there to nurture? In the qualitative aspect, student schemas are much more meaningful if they are not coerced (Pushkin, 1995). Is this a "cognitive apprenticeship" (Damarin, 1993)?.

> In this model the student is bound in service to the expert; the goal is not (necessarily) that the student become the expert, but the student learn the art or trade which serves the reproduction and reification of expertise. (Damarin, 1993, p. 30)

According to Joe Kincheloe (1992), "Schools are the guardians...to institutionalize the attitudes necessary for the industrial discipline which leads to increased productivity" (p. 228). When we discuss "functional literacy," how do the powers of a school system define it? Has the context changed with the times (McLaren, 1992)?

> Student knowledge is based on the notion of replication rather than interpretation, as students are deemed 'to know' only when they can display a fragment of data at a teacher's bidding. Schools reflect positivist assumptions when they affirm that the most significant aspects of school can be measured. In their positivist tunnel-vision objective tests deny students a chance to transcend the reductionism of measurability, they cannot in this context respond creatively, develop a relationship between their lived experience and the information, or learn intrapersonally by establishing a personal position on the issue.
>
> Such an approach encourages a stimulus-response reflex, erasing the totality of the person from the learning process. In the positivistically defined school, student subjectivity is viewed with suspicion if not hostility. (Kincheloe, 1991, pp. 64-65)

Kincheloe (1993), in his book *Toward a Critical Politics of Teacher Thinking*, states: "Students of modernism's one-truth epistemology are treated like one-trick ponies, rewarded only for short-term retention of certified truths (p. 3);" and "When behavioral psychology was added to the pedagogical recipe, teachers began to be seen more an more as entities to be controlled and manipulated." (p. 7). Why are learners taught obedience? Perhaps their teachers do not know any better; they are a product of a self-perpetuating paradigm.

The postmodern condition is more than an issue of manipulation. It is an issue of enculturation to the path of least resistance, efficiency, and conformity. The result is a system of *haves* and *have nots*, ignorant of which they are. The system neatly created by insiders essentially makes everyone an outsider, unaware the insiders abandoned the system on autopilot. Disenfranchisement exists at all levels of the hierarchy.

Social Constructivism

Social Constructivism is essentially an amalgam of cognitive and educational philosophies, developed internally by schema refinement, but influenced externally by social discourse. Although a variety of theories potentially contribute to this epistemology, Constructivism offers us all an opportunity to individually formulate theoretical frameworks and internalize a meaning and purpose (Pushkin, 1997d). Without a context for learners, learning fails to have meaning in a culturally diverse community.

Deborah Walker and Linda Lambert (1995) offer a wonderful historical background on the foundations of this epistemology. They credit the beginnings of constructivism with John Dewey's 1916 book *Democracy and Education*. Although the term "constructivism" was not part of his language, Walker and Lambert (1995) point out that Dewey was truly the first educator to address the issue of how children developed an understanding of knowledge and how schools and teaching should foster this development.

> Constructivism is a theory of learning, and it is also a theory of knowing. It is an epistemological concept that draws from a variety of fields, including philosophy, psychology, and science... at once a theory of 'knowing' and a theory of 'coming to know.' (Walker and Lambert, 1995, p.1)

When Jean Piaget first articulated the theory of constructivism in the 1960s, it was presented with a biological perspective (e.g., Lawson, 1994). Organisms learn by encountering new experiences and events, assimilating these experiences into previous knowledge, and accommodating the new knowledge produced. Based on this theory, learners' cognitive structures (i.e., schemas) are continuously formed and re-formed, the consequence of various experiences, beliefs, values, socio-cultural histories, and preconceptions. Without "disequilibrium (e.g., discrepant events)," cognitive growth and development could not take place (Piaget, 1972; Walker and Lambert, 1995).

While many apply constructivism as a Piagetian creation, Jerome Bruner, Lev Vygotsky, and Reuven Feuerstein also contribute to the constructivist theory (Walker and Lambert, 1995). The process of "coming to know" is influenced and shaped to a degree by personal reflections, mediation by educators, and social interactions among peers.

Bruner, in the book *Making Sense*, analyzed the changes taking place within developmental psychology as children were becoming viewed more as "social beings." Perhaps a reflection of the backlash towards *The Process of Education*, or realizations after a decade of observing public school education during his curriculum reform movement (Bruner, 1971), language, culture, and social class were identified as key issues shaping the context of learning.

Vygotsky proposed a "zone of proximal development," or "learning curve" (e.g., Driscoll, 1994; Pushkin, 1997e; Walker and Lambert, 1995). To Vygotsky, all learners have a capacity to learn, but at different rates. Although mediation and social interactions are important, all learners need sufficient time to "come to know;" knowing is neither universal nor finite.

Feuerstein conducted extensive studies with children survivors of concentration camps after the second world war; significant cognitive gaps were observed. Personal trauma does indeed construct a context for knowledge and ways of knowing (Simmers-Wolpow, 1995).

Because of the significance of social interaction and mediation, constructivist theory is more precisely *Social Constructivism*, primarily because of its pedagogical application. However, there is more to this than we realize. The classroom teacher is perhaps the most important component to the classroom environment. Although constructivism is primarily viewed in terms of 'student-centered' versus 'teacher-centered' pedagogy, it is the teacher who essentially dictates the learning culture, cognitive expectations, and curricula. Students are made aware of these cultural, cognitive, and curricular matters through classroom interaction (i.e., the syllabus, class discussions, feedback on assessment items). There is an active exchange between vested parties; students and teachers are direct participants in the education process (i.e., teaching and learning); knowledge is not independent of the knower (Kincheloe, 1993).

> Therefore, social constructivism is more than a theory of "coming to know." It is more than a theory based on personal contextualization. It is a pedagogical and curricular manifestation of the socio-cognitive influences -- internal and external -- on teachers and learners. How learners interact with each other, teachers, and the culture of education can be as much an influence on schema development as biological, cognitive, and emotional maturity. (Pushkin, 1997d, p.4)

Learners not only have a socio-cognitive baseline prior to learning experiences, but that baseline requires careful interaction in order to build beyond. In some cases, prior external influences (e.g., trauma) may be potentially impossible to overcome (Simmers-Wolpow, 1995). Internal influences present similar challenges, as research documents the staying power of many preconceptions and misconceptions.

However, internal influences are not very different from external influences, in the sense that mediation is a key means towards challenging schemas. Although the focus on our teaching should be on the students, there are boundary conditions that include teachers and the educational establishment of cognitive and curricular expectations. Teachers need to interact with students just as students need to interact with each other. The classroom is a *community of learners*, regardless of the academic position or status of each member. Each member of the community experiences personal growth at individual rates; cognitive maturation is a long-term individual process.

Two additional theorists can be associated with social constructivism: William Perry and Lee Shulman. Perry (1970) observed and identified four stages of cognitive development in college students: Dualism, Multiplicity, Skepticism, and Relativism. One does not evolve from one stage to another without the benefit of dialog. This is essentially the key to Shulman's PCK; successful teachers interact with their students, not subject matter. In each theory, the significance of socio-cognitive influences is apparent.

Dualistic learners see things in dichotomous terms. Because of this cognitive perspective, they are more likely to defer to an arbiter of knowledge; their schemas are based on the authority of experts. Multiplistic learners tend to see beyond dichotomies, yet still defer to authority when challenged.

Skeptical learners begin to identify the strengths and weaknesses of knowledge, and are more likely to challenge than accept knowledge. Relativistic learners not only see knowledge through a discerning eye, but can respect knowledge regardless of its strengths or weaknesses, or its acceptability. To reach the relativism stage, learners need to exchange and examine knowledge; this cannot take place without some form of social interaction, be it with other learners or teachers. Cognitive growth is a manifestation of communication, essential to the human condition.

Critical Thinking

Critical thinking can involve attributing, comparing/contrasting, classifying, analyzing for bias, solving for analogies, and evaluating. This is most-relevant to successful problem solving, as it appears to manifest situated cognition. Situated cognition itself is essentially a level of understanding that transcends qualitative and quantitative reasoning. Such understanding involves the recognition and distinction of contexts; context determines whether strategies are appropriate or not.

> Situated cognition is essentially a level of understanding that transcends qualitative and quantitative reasoning. Such understanding involves the recognition and distinction of contexts; context determines whether strategies are appropriate or not. One could determine the electric potential for a fixed point charge in space via Gauss' law; this cannot be determined, however, by employing Ohm's law. (Pushkin, 1997f, p. 4).

How is situated cognition applied in the classroom? How do we promote it? How can we help students develop it? This is where our individual epistemologies come into play. If we conform to traditionalism beliefs in rote memorization, objective test assessment, and algorithmic calisthenics, we fail in many respects.

First, we fail with respect to the postmodern view of education. Traditionalists look at content knowledge as something sacred, something beyond ourselves and our students. They transmit this sacred knowledge, and expect students to blindly accept it and conform to its arbitrary meanings.

Second, we fail with respect to constructivism. Traditionalists look at knowledge as sacred, and assessment as a means of ranking students according to the 'rightness' or 'efficiency' of their answers. They believe in the bottom line; the result means more than the process. They don't believe in mediation to serve students' zones of proximal development; they believe in mediation to dispense a standard, essentially forcing students to defer to and worship authority.

Third, we fail with respect to PCK. Traditionalists do not believe in placing a context on learning or knowledge. The syllabus is absolute, independent of teacher, student, or academic environment. Students are taught the course content as a function of the absoluteness of knowledge. The curriculum and pedagogical practices remain the same; students must evolve and conform.

Last, we fail with respect to critical thinking. Traditionalists do not believe creativity, analogies, and comparisons are of much value. There is no interest in learners' abilities or inclinations to apply what is learned; they simply want validation of what is taught.

If we believe beyond the traditional approach, and subscribe to critical thinking, we do find value in authentic assessment, PCK, social discourse, and the significance of learners and teachers. We believe in providing students meaningful opportunities to test their ideas and develop understanding. We believe in designing syllabi and learning activities around our student population. We believe in challenging our students and ourselves to be part of a *community of learners*.

Learners' thinking skills are very much a function of the learning culture. Thinking skills are a function of pedagogical fostering. Pedagogical preactices are a function of epistemological cultures, racist or not. What kind of learners do we desire for our learning cultures? What kind of thinking do we want to promote? Are we a culture of opportunity and growth, or conformity and limitations?

RESEARCH QUESTION

What are the socio-cognitive influences -- internal and external -- guiding General Chemistry students' learning and success?

- ***To what degree is pedagogical practice a factor?***
- ***To what degree is the syllabus a factor?***
- ***To what degree is academic background a factor?***
- ***To what degree is self-esteem a factor?***
- ***To what degree is maturity (cognitive, emotional, or academic) a factor?***

METHODS

Population Demographics

According to Fall 1997 enrollment data, MSU reports approximately 2,500 undergraduate science and math majors of African-American or Latin-American ethnicity. 127 undergraduate students currently participate in the HCP at MSU, the majority as Biology, Chemistry, or Biochemistry majors. Approximately one-third of these students maintain a Grade Point Average (GPA) of at least 3.00; approximately

another third maintain a GPA between 2.50 and 2.99. Of HCP students, 41 are seniors, 25 are juniors, 29 are sophomores, and 32 are freshmen. It is among these 32 freshmen that our attention is focused.

All 32 freshmen HCP students matriculated to MSU in June 1997, 11 males and 21 females. Of the males, 8 were of African heritage (one from Liberia, West Africa); 3 were of Latino heritage. Of the females, 15 were of African heritage; 6 were of Latina heritage.

Academic Foundations

Class Placement:

Students are administered a Mathematics Basic Skills placement test at the beginning of their 6-week summer experience. On the basis of placement test scores and SAT Math scores, students were either placed in a Basic Skills I class, Basic Skills II class, Intermediate Algebra class, or Pre-Calculus class.

Basic Skills I and II classes primarily address fundamental computation and elementary algebra. The Intermediate Algebra class primarily addresses sets, functions, and algebraic operations. The Pre-Calculus class primarily addresses functions, exponential relations, logarithms, and basic trigonometry. Each class is part of a sequence; ideally a new HCP freshman should be in Pre-Calculus, preparing to take Calculus during their first year of coursework. Successful completion of a summer class enables students to begin the fall semester with the next math course.

6 students were placed in the Basic Skills I class, 4 males (1 Latino) and 2 females (1 Latina). 4 students were placed in the Basic Skills II class, 2 males and 2 females (1 Latina). 6 students were placed in the Intermediate Algebra class, 3 males and 3 females (1 Latina). The remaining 16 students were placed in the Pre-Calculus class, 2 males (both Latino) and 14 females (4 Latinas).

In addition to their math course, all HCP freshmen take a chemistry course (CHEM 107, College Chemistry I) in preparation for CHEM 120-121. Few HCP freshmen matriculate to MSU with a strong background in chemistry; many did not even have a high school chemistry experience, much less a physics experience. The summer version of CHEM 107 primarily intends for students to address the following fundamentals of chemistry:

- The Periodic Table
- Atomic Structure, Ions, and Molecules
- Units of Measurement and Calculations
- Chemical Formulas
- Chemical Reactions
- Balancing Chemical Equations
- Stoichiometric Relationships

These are the core concepts students encounter and apply in CHEM 120-121, especially in the context of problem solving, a top priority of DC&B faculty.

Enrollment in CHEM 120-121 depends on successful completion of the CHEM 107 summer course. Students failing CHEM 107 are required to repeat it during the fall semester (followed by CHEM 108, College Chemistry II, during the spring). CHEM 120-121 enrollment is delayed until satisfactory completion of CHEM 107-108.

Cognitive Development:

Successful problem solving requires four types of schema-specific knowledge: (1) declarative, (2) procedural, (3) situational, and (4) strategic (e.g., deJong and Ferguson-Hessler, 1986; Maloney, 1994; Schoenfeld, 1978). Studies indicate successful problem solving reflective of a more procedural and situational orientation; less successful problem solving indicates a more declarative orientation (Chi et al., 1989; Ferguson-Hessler and deJong, 1990). Essentially, successful problem solving depends on sensitivity to context and metacognitive strategies. These factors are significant in relation to the *Expert-Novice Paradigm*.

Declarative knowledge essentially consists of arbitrary facts one tends to memorize and reiterate on objective assessment items. Procedural knowledge essentially consists of rules and algorithms, such as steps in a procedure or algebraic manipulations. Procedural knowledge also tends to be memorized and reiterated during assessment.

Situational knowledge, on the other hand, can be synthesized and applied. This type of knowledge focuses on the *context* of what we encounter in problem solving. Problem solvers question the context of the problem: *what is the concentration? what is the initial temperature? is the pressure important?* By considering the context of the problem, students are considering specific declarative and procedural knowledge; the scope is limited to what is relevant and useful.

Strategic knowledge is the ultimate in synthesis and application. With experience, students should comprehend that one does not use the Ideal Gas Law to solve an Acid-Base problem; nor does one use pH to determine the molar mass of oxygen. For each situation, students must apply specific strategies. Although one needs command of declarative and procedural knowledge to develop situational and strategic knowledge, the latter is what separates successful problem solvers from others. They are the *critical thinkers;* they have developed what is known as *situated cognition.*

Introductory students tend to be very algorithmic in their attempts to understand chemistry (Pushkin, 1998b). This is the consequence of the dualistic nature of novice learners, portraying science as a body of facts and rules to memorize and mimic. Conceptual understanding, a desired outcome of critical thinking, has low priority among introductory students. Unfortunately, a General Chemistry curriculum emphasizing mastery of calculation exercises fails to foster critical thinking skills development and conceptual understanding.

Because a number of HCP freshmen matriculate to MSU lacking strong backgrounds in math, chemistry, and physics, a third experience was added for the first summer. Curricula that do not foster critical thinking fail to serve students, especially students equating academic success with retention and future opportunity. Opportunity, the ultimate concern of the HCP and its students, is often denied or inaccessible; foundations needed to be strengthened in a broader sense.

This third experience is known as the "Critical Thinking Workshop." Although no academic credit was gained from this course, it was mandatory for all HCP freshmen. Each student received an official letter grade which HCP advisors used for reference purposes as freshmen grades are evaluated. It was wondered if poor academic grades in math and physical science courses during the freshman and sophomore years might correlate to their "Workshop" grade. CHEM 107 and math courses during the summer may have a limited scope of content coverage, giving HCP advisors and students a false sense of grade validity. A course approaching math and science from a more in-depth, interdisciplinary application, is perhaps a stronger indicator of student learning.

All HCP freshmen met together each Wednesday afternoon for 2 hours during the 6-week summer session. Students were organized into groups of 4, where gender and math placement were taken into account for relative group equity. Each weekly meeting explored a specific theme:

- What is Critical Thinking?
- What is Problem Solving?
- Chemistry and Problem Solving.
- Physics and Problem Solving.
- Review of New Concepts.
- Solving a Challenge Problem.

The class was taught from a Social Constructivist perspective; students were encouraged to be active group and class participants. Discussions primarily focused on characteristics of problems, employing critical thinking skills for analysis, sharing questions and ideas, and taking risks. Students needed to understand that risk taking was not necessarily bad; risk taking may lead to better ideas after an initial idea fails. Nothing is gained from not trying; nothing is really lost by risk taking.

Assessment:

During the third, fourth, and sixth weeks, students were given problems to solve in groups, as well as individual quizzes. Problems specifically presented varied contexts and integrated concepts. Students' ability to recognize, distinguish, and employ appropriate strategies was emphasized; how students determined answers meant more than what the answers were.

Students, unfortunately, did not appreciate the priorities of the course. Having the correct answer was more important to them; not having the correct answer was equivalent to no answer. All-too-often, students left problems untried; some even handed in completely blank papers. Some openly questioned the value of the course, concluding a grade that did not count towards their GPA should not be taken seriously. This unexpected attitude was significant in our study, and is discussed later. The consequence of students' decisions resulted in very disappointing grades for the course. The highest grade earned was a C+; the majority of students earned a D for the course.

Such low grades caused alarm for HCP advisors, as students typically earned A and B level grades for CHEM 107 and their math course. In fact, 24 of 32 students were recommended to take CHEM 120 in the fall, even though 5 were not qualified to take Pre-Calculus, a recommended co-requisite.

Advisors were not sure whether grades needed to be interpreted from a different perspective. Students were absolutely certain their "Workshop" grade was a reflection of unrealistic expectations and punitive pedagogical practices. One student specifically stated "This is sick. I hear chemistry is nothing like this except when professors like you teach it. Chemistry isn't supposed to be hard." A number of freshmen were scheduled to take CHEM 120 in the fall with the same instructor (the principal investigator); their low grade caused them to change instructors for CHEM 120, seeking an instructor better associated with grade inflation. This is also significant with regards to our study, and will be discussed further in a later section.

The issue of students leaving problems, or entire papers, blank was very troubling. However, it was indicative of a lack of confidence and perceived significance by students. After discussion with a few students on this matter, it was expressed that "taking a zero" was always better than "doing it wrong." By taking a zero, students did not risk negative feedback for an incorrect answer. They likened it to the infamous biting incident by Heavyweight boxer Mike Tyson. By being disqualified, Tyson could at least say his opponent (champion Evander Holyfield) did not "beat him." Losing by forfeit is apparently more acceptable than suffering defeat. Despite all the encouragement to take risks and try solving problems, students thought only their answers mattered. This reflects their dualistic view that science is a body of facts and rules for memorization and reiteration. If science is viewed in "black-and-white" terms, why would answers be viewed any differently? Students viewing themselves as outsiders in the learning culture reinforce this by contributing as little as possible, since little expected is the prevailing assumption.

Study Sample Population

24 HCP freshmen enrolled in CHEM 120 for the fall 1997 semester; 13 (9 females, 4 males) enrolled in sections (#9 and 10) taught by the principal investigator.

Section #9 (11 students):

8 females (4 African-American, 4 Latina)

3 males (1 Liberian, 1 African-American, 1 Latino)

- 4 students not enrolled in at least Pre-Calculus:
  - 2 males (1 Liberian, 1 African-American)
  - 2 Latin-American females

Section #10 (2 students):

1 African-American female

1 African-American male

Student Surveys

Epistemological Structure:

Sections #9 and 10 were taught from a Social Constructivist perspective, both in the double-section lecture class and single-section lab classes. Lecture format was predominantly discussion-based, where students and instructor work collaboratively on content, exploring concepts, and solving problems. The pace of the course was flexible, as expectations were for this classroom culture to develop gradually during the semester. Priority was placed on developing understanding versus amount of content coverage. Although such an approach seemed inefficient to other DC&B faculty, the entire syllabus was covered by the end of the semester (of note, the only sections to do so).

The Social Constructivist laboratory is the forum for the most creativity and student freedom. This is the primary place to challenge students and provide various opportunities to develop situated cognition (Pushkin, 1997e). Such opportunities are not enough; for a pedagogical influence to have long-lasting cognitive impact (i.e., explicit instruction), that influence needs to be a regular part of the course culture (Jonassen, 1993; Pushkin, 1995). Although reform is preferable in small doses by the majority of university faculty (e.g., Burke, 1997; Domin, 1997; Glazer, 1997), such a gradual progression will indicate minimal value until a generation experiences the full effect. Occasional "different" learning experiences eventually appear to students as "gimmicks" or "special activities," treated as exceptions to the course culture. If the intention is for innovative learning experiences, course syllabi should consistently and continuously reflect this.

Students can be given enormous degrees of freedom to create their own investigations and protocols. By initially discussing underlying principles as a group, students can make their own decisions with minimal guidance. Students need these opportunities; such opportunities enable them to develop stronger and more independent thinking skills (Pushkin, 1997e).

This is much more feasible in a physics laboratory setting than chemistry. The predominant constraints one encounters when incorporating constructivism are:

- Entrenched dependence on "cookbook" lab manuals
- Entrenched belief students cannot master the recipe
- Entrenched paranoia about safety
- Entrenched obedience to inertia
- Entrenched aversion to nonconformity

As a result, laboratory experiences for students failed to fully incorporate the desired constructivist perspective, which limited the opportunities to acquire significant data on problem solving skills. This was personally disappointing, since constructivist-based lab activities were designed collaboratively by the principal investigator and undergraduate students having taken CHEM 120-121 the year before. A great deal of valuable data, fortunately, was acquired regarding students' attitudes and beliefs about teaching, learning, and expectations in a university-level science course. It is this data that provides the most valuable insights for this study.

Epistemological Explorations:

On the first day of the semester, CHEM 120 students in sections #9 and 10 were administered a survey asking students to provide background on themselves (e.g., who they were, what their major was, what year in college were they in are taking CHEM 120, and prior experience in science/math). However, this survey also included the following questions:

- **What are your expectations for this course?**
- **Expectations of YOU?**
- **Expectations of your instructor?**

Almost every one of the 13 HCP freshmen essentially responded:

- *Get an "A" in chemistry.*
- *Give enough right answers on tests to get an "A".*
- *Teach me how to give the right answers!*

A few students also expected their instructor to be patient and fair, and help them in every way possible to achieve the grade they desired for the course. They additionally requested that the course be taught very slowly and tests not be too difficult. Based on this initial survey, it was clear that these freshmen placed enormous weight on GPA and science as a body of facts and rules to memorize and reiterate. However, it was also clear that these freshmen believed their achievement depended more on the instructor than themselves. This reinforces the perspective that students are outsiders within their learning culture, having no locus of control for their own intellectual growth.

Concluding each weekly lab activity, students were administered a 5-point Likert scale questionnaire regarding their perceptions and attitudes towards lab-based learning. This anonymous questionnaire was derived from the Instructional Materials Motivation Survey (IMMS) developed in the 1970s by John Keller at Florida State University. Our version of the IMMS is on page 27.

The purpose of this questionnaire is to determine what features of lab activities, or entire lab activities, best serve students' learning from their perspectives. The questionnaire addresses four specific affective aspects relevant to learning: student attention, student confidence, student relevance, and student satisfaction. According to Keller's design, the questionnaire should have a relatively equal distribution of items among affective aspects. It is also important for the questionnaire to present both positive and negative statements regarding the same aspects, to ensure that students do not indicate contradictions about their views. Students were also invited to write additional comments on their surveys.

It is also important to note the five-point scale was used to allow students the opportunity to take a neutral stance. If one investigates evolving student perspectives, it would be hypocritical to force students to take definite positions when they are not necessarily ready to commit (Pushkin, 1995). Students were surveyed ten times during the semester, and subjected to other modes of assessment, allowing time for opinions to form and solidify.

Prior to the last weeks of the semester, students were assigned a "Lab Reflective Essay." The purpose of this assignment was three-fold. First, it was important to solicit more in-depth views from students regarding their learning experiences and expectations. Second, it was important to confront students with self-examination of their own intellectual growth. Third, it was important to allow students to openly share their views on an assignment that would not involve academic "penalty" (all students, including the 13 HCP freshmen, received a grade of 100 for completing the assignment). The text of this assignment is on page 28.

CHEM 120 – Post-Lab Activity Questionnaire

(1) Attitude survey for students to rank learning materials, chemicals, and equipment.

(1) Not true **(4) Mostly true**

(2) Slightly true **(5) Very true**

(3) Moderately true

(2) Items reflect the following student areas:

Confidence to Learn: #1-3, 5, 11 Attention to Task: #7-9, 12-13, 16

Relevance to Goals: #4, 6, 10, 14-15, 17 **Satisfaction of Lab: #18-21**

(3) Items #14, 15, 18, 19 are modified to reflect the specific lab activity!

1) When I first looked at the handout, I thought this lab activity would be easy for me.

2) The concepts were more difficult to understand than I would like for them to be.

3) After reading the handout, the learning goals for this lab activity were clear to me.

4) It is clear to me how this lab activity relates to things I already knew.

5) The handout had so much information that it was hard to pick out and remember the important points.

6) Successful completion of this lab activity was important to me.

7) The quality of writing of the handout helped to hold my attention.

8) This lab activity is so abstract that it was hard to keep my attention on it.

9) The handout looked dry and unappealing; the writing was rather dull.

10) The concepts in this lab activity are relevant to my interests.

11) The calculations for this lab activity were too difficult.

12) This lab activity stimulates my curiosity as a science student.

13) The instructions were vague and difficult to understand.

14) How the handout was written gave the impression that certain chemical concepts are worth knowing.

15) How the handout was written gave the impression that certain procedures are worth knowing.

16) I learned some things that were surprising or unexpected.

17) The style of writing in the handout was inappropriate for the type of student I am.

18) This lab activity helped me see certain chemical concepts from a different perspective.

19) This lab activity helped me see certain procedures from a different perspective.

20) It was a pleasure to experience such a well-designed lab activity.

21) This lab activity should be permanent for CHEM 120.

BEST COPY AVAILABLE

CHEM 120 -- Lab Reflective Essay Assignment

The purpose of this assignment is to make you think and reflect back on your learning experiences in the lab for this semester. Reflection is a part of critical thinking that allows all of us to compare where we are now as learners and thinkers at the end of a course, to where we were at the beginning of this course. We all like to think we've grown during a semester, but growth is viewed differently for different people. Growth can result from both positive and negative experiences or accomplishments. Somehow, somewhere, you have all experienced growth (perhaps even some warping?!); it's up to you to personally identify that growth.

As you write your essay, the minimum requirements MUST be met:

(1) Typed and double-spaced!

(2) At least 1000 words (approximately 4 pages).

(3) Appropriate Grammar, Spelling, and Vocabulary!

There is no limit to how long the essay can be. Some of you may have more to share than others (just try to keep it from getting too heavy and causing a hernia to lift!).

There are many ideas that you could possibly address in your essay, and there is no limit as to what is allowed. However, you should consider the following questions when writing:

(1) How have your experiences helped you grow as a chemistry student? Why?

(2) What goals do you plan to establish for future chemistry courses, or any course if this was your last chemistry course? Why?

(3) What did you like most from lab? Least? Why?

(4) What recommendations might you make for the General Chemistry program, or department in general? Why?

A last mode of assessment used was the instructor/course evaluations students completed at the end of the semester. Although anonymous, general themes could be inferred from response distributions, especially in section #10, which was dominated by HCP freshmen. It should be noted that since the post-lab questionnaires were also anonymous, specific response trends in section #10 could be compared with the instructor/course evaluation responses. Crude comparisons could also be made between response trends and overall course grades in section #10. Since the issue of grades was significant for HCP freshmen, perhaps some informal correlations can be drawn.

Methodological Framework:

> To assert that something has method is to claim that there is an order, a regularity, obscure though it may be, which underlies an apparent disorder, thus rendering it meaningful. Method is the attribute which distinguishes *research* activity from mere observation and speculation... There will be no way to properly compare one inquiry with the other. It is for this reason that major controversies in educational research so frequently focus on problems of research method. What is the role of research methodology in educational research? How can we tell proper from improper uses of research methods? (Shulman, 1988, p. 3)

Qualitative and quantitative research can be either mutually incompatible or highly complementary (Borg and Gall, 1989). However, as Borg and Gall (1989) state: "the research designs used by many investigators do not fit either model to the exclusion of the other but instead use some combination of these paradigms" (p. 383). They introduce five areas related to educational research where the two paradigms have different assumptions:

(1) The nature of reality:

The quantitative (or *positivistic*) paradigm looks at learner characteristics as a collection of individual constructs that can be examined separately, predicted, and controlled; the qualitative (or *naturalistic*) paradigm considers the whole greater than the sum of the parts.

(2) The relationship between researcher and subject:

The quantitative paradigm looks at the researcher-subject relationship as minimal; the qualitative paradigm views the relationship as symbiotic.

(3) The opportunity to generalize:

The quantitative paradigm views generalizations as the ultimate goal; developing a unique profile of a learner is important to the qualitative paradigm.

(4) the possibility of causal linkages:

The quantitative paradigm views the cause-and-effect relationship as the source of validity; specific cause-and-effect relationships are not as clear to the qualitative paradigm.

(5) the role of values in inquiry:

The quantitative paradigm seeks methods free of value, opinion, and bias; such attributes shape the context of research for the qualitative paradigm.

Furthermore, they present ten characteristics most associated with qualitative research:

(1) Research involves holistic inquiry carried out in a natural setting.

(2) Humans are the primary data-gathering instrument.

(3) Emphasis on qualitative methods.

(4) Purpose rather than random sampling.

(5) Inductive data analysis.

(6) Development of grounded theory.

(7) Design emerges as the research progresses.

(8) Subject plays a role in interpreting outcomes.

(9) Utilization of intuitive insights.

(10) Emphasis on social process. (pp. 385-386)

No statistical algorithm can justly identify the paradigms a student expresses; algorithms cannot distinguish the delicate differences between responses. Although questionnaire responses were quantified in order to illustrate possible trends among students' responses, quantitative research methods (e.g., null hypotheses, tests for significance, and error types) were inappropriate for this study.

Theory may or may not "emerge" from data (Hammersley, 1992), but can data emerge from a theory? Do we operate from a preconceived bias or intuition? To what degree can such studies be validated?

A study, such as this one, is motivated by a perceived dysfunction by certain faculty, academic advisors, and students. To what degree is our perception "real"? Perhaps this dysfunction is a function of faculty entrenched by traditional pedagogy and curricula. Perhaps it is a function of epistemological racism and low expectations. Perhaps it is a function of lacking motivation and/or appreciation at a university.

Several parties have a vested interest in CHEM 120-121; causality has many possibilities. This study seeks to identify possible sources for a collective dissatisfaction.

What shapes such a study? Does a theoretical framework already exist, or does a researcher work on hunches? Is it better to approach the study with an open and flexible mind? We seek to make theoretical inferences from our data; the scope of data must be as broad as possible until we can appropriate narrow that scope.

What is the limitation of only one test or context (Hammersley, 1992)? By this, we must be sensitive to qualitative studies being unique and contextual. What about generalizability? Is it better to have it or not? If generalizability is not possible, does this devalue the findings and prohibit meaningful comparisons? Or does it challenge us as researcheers to be more insightful and creative in our attempts to apply the work of others?

A potential drawback to structuring ethnographic, phenomenological, or simple qualitative studies for generalizable purposes is such studies become contrived. Artificially creating a population to enable researchers to make strategic comparisons may result in a degree of validity, but that validity is itself artificial. It is meaningless to structure a study that poorly portrays the "real" learning culture; identifying "real" sources of causality is less probable. Although "real" and "perceived" sources can be challenging to distinguish, researchers minimize the probability of making error-free distinctions based on contrived conditions and observations. The dilemma we all encounter is whether to represent reality or reproduce it (Hammersley, 1992). Our answer depends on our research goal. What is it we wish to learn from a school situation, and what outcomes/remedies do we wish to influence?

This is neither an attempt at grounded theorizing or analytic induction. Employing, or attempting to employ a hypothetico-deductive mode creates a myopia for researchers, potentially precluding them from seeing beyond initial assumptions. Our efforts could be for naught if we overlook what could be the true essence of a learning culture. For results to be meaningful and purposeful, researchers need to make connections between observations, analyses, interpretations, and relevant theories. This should be our standard for validity -- the degree of connectedness in a study. The meaningfulness of this study is to learn about classroom environments as they truly exist. As stated by William Perry (1970): "The dictum drawn from LeChatelier holds: 'If you want to learn about a system, try to change it'" (p. 85); the functionality of a learning culture depends on its resistence to perturbation.

FINDINGS AND DISCUSSION

Tell us what you want to hear, and we'll tell you what we think; no phrase best typifies the mind-set of college freshmen (Perry, 1970; Pushkin, 1995). However, in the case of HCP freshmen, attempting to practice this mind-set actually provided insights to what they really thought. Enculturing students to a Social Constructivist perspective encourages the development of student consciousness and openness. To some degree, student consciousness was stimulated; to a large degree, student openness was stimulated. The degree of student internalization is debatable.

Of the 10 lab activities CHEM 120 students participated in, 8 reflected some constructivist-based approach; the other 2 were traditional labs done by the rest of the CHEM 120 sections. On the other hand, 2 constructivist-based labs were done by the rest of the CHEM 120 sections along with their 8 traditional activities. Very little questionnaire data was available from the other CHEM 120 lab sections; however, it was evident that students from the other sections were more receptive towards the constructivist-based labs than the traditional ones.

The weekly post-lab questionnaires provided potentially interesting insights regarding HCP freshmen. The 11 students in CHEM 120 section #9 accounted for approximately half the class list; this section had a higher proportion of freshmen in general compared to section #10. On a weekly basis, overall responses from section #9 were more opinionated, more extreme, more negative, and more contradictory than from section #10, which had a very large proportion of older students (juniors and seniors). Only section #9 students provided additional written feedback on questionnaires; this feedback was fairly negative in tone.

For example, section #9 responses were typically further away from the neutral point of the scale, with a higher proportion of "Not true" and "Very true" responses. Section #9 responses were typically more negative with regard to items addressing student confidence, relevance, and satisfaction. Section #9 responses were especially negative towards the design and objectives of each lab activity, specifically negative towards less-detailed procedures outlined in lab handouts.

Section #9 students consistently complained that directions were missing and unclear, prohibiting them from "doing the lab correctly." The most-extreme responses reflected items 3, 6, 11, 13, and 15; items specifically addressing aspects relevant to objectives, results, algorithms, and procedures. Novice learners may be particularly sensitive toward such items; students typically wanted exact objectives, "correct" results, easy calculations, and fool-proof techniques. By knowing exactly what the

instructor expected of them, students could efficiently reproduce those expectations and receive a good grade. Any degree of uncertainty resulted in considerable discomfort with the lab activity, dissatisfaction with observations and results, and frustration with decision making. Students preferred lab activities to be *hands-on* only, without *minds-on* requirements.

Interestingly, section #9 students expressed their most positive responses towards the 2 traditional labs encountered during the semester. A number of students even wrote on their questionnaires that these 2 lab activities were exactly what lab activities should be in chemistry. Unfortunately, these 2 lab activities resulted in the poorest lab report grades of the semester, due to large measurement and calculation errors. As much as they enjoyed these lab activities, with detailed step-by-step procedures, it was evident from their analyses that they did not comprehend key ideas or techniques. Simply following directions was not enough; students needed to think about the chemistry involved with each step for results to have meaning.

In addition to doing poorly on preferred lab activities, section #9 students provided other contradictory patterns. For example, while responding favorably to item 1 (re: ease of activity) they responded equally to item 2 (re: difficulty of concepts). The same observation was made regarding items 7 and 8 (re: attention to, and quality of handout).

The most notable responses reflected items 14, 15, 18, and 19. Section #9 students responded much more favorably to items relevant to the process of obtaining results (15 and 19), and much less favorably to items relevant to the underlying concepts (14 and 18). Essentially, section #9 students indicated that getting the answer itself mattered much more than the principles behind the answer. This was very evident during the second and third lab activities of the semester.

The second lab activity involved the determination of a hydrate's formula, where heating a sample resulted in a water loss used for calculation purposes. Almost all of the students neglected to subject their sample to consecutive heatings, resulting in inaccurate water losses and calculated formulas. Although lab report grades were tolerant of this student oversight, a number of HCP freshmen were visibly distraught by this oversight being addressed in detail in the form of written feedback. Rather than look upon this feedback as a "live and learn" experience, they made it an issue of being "wrong," resulting in anger that they were not completely aware of "how to do it right."

A consequence of this was during their third lab activity, which involved determining the percentage of Copper in a compound. Although the techniques and concepts were somewhat unrelated, these students made it their mission to do

everything "perfectly." In fact, some students actually used the same algorithm of analysis appropriate for the previous week's lab activity.

This was when the high importance of how to get the answer became prominent and persistent. It had little to do with minimizing experimental error yet everything to do with lab report grades and reward from the teacher. Essentially, these students interpreted corrective feedback as motivation to please their authority, the instructor, the *arbiter* of their academic success. It is also likely they were motivated by their negative feelings towards corrective feedback. Many of these students were the same ones who preferred leaving problems blank during the summer "Workshop;" a lack of confidence can motivate students to avoid taking risks and accepting subsequent critique.

Overall, post-lab questionnaire responses indicated the younger students (predominantly in section #9) were more process-oriented, grade conscious, and direction-needy than the older students (predominantly in section #10). This correlates to a significant degree with the expectations HCP freshmen stated on their initial course surveys ("Teach me how to give the right answers"). They preferred to be told what to do, how to do it, when to do it, and what to learn from it; the older students preferred to explore, digest, and derive understanding. Although older students had their share of anxieties in the lab, they were more even-keeled than their younger counterparts.

> Constructivist learning environments may frustrate students who have shallow motivations for academic work (completing tasks for the purpose of receiving a grade or besting others) because there is no correct answer, specific task requirements are not furnished for them, and there is difficulty quantitatively comparing understanding among students. Students who have more sophisticated motivations to understand the material profit from the constructivist approach, but may also be frustrated by the relatively unstructured nature of constructivist learning environments.
> (Windschitl and Andre, 1998, p. 148)

> Epistemologically less mature students believe that knowledge is simple and certain. An instructional approach that provides overly prescribed instructions as to how to proceed and leads students to specific conclusions would be consistent with these students' approach to knowledge. The confirmatory approach followed that instructional model. Epistemologically less mature students should find less compatible an approach that emphasized self-exploration and self-construction of knowledge. (Windschitl and Andre, 1998, p. 156)

Although we continue to make sense of post-lab questionnaire responses and determine further meaning regarding the cognitive development of college students, evidence suggests freshmen have more narrow and dichotomous views than older students. Although students still tend to graduate college with similar views, it is possible those views may broaden and differentiate to some degree with time. Whether this is due to experience, maturity, or assimilation requires further examination.

The Reflective Essay assignment provided perhaps the most intriguing insights. Many students shared how much they grew during their first semester of college, particularly within the areas of study habits and problem solving. Three students specifically stated how well-prepared they were for future chemistry courses (each student earned a 'D' for CHEM 120). Several bemoaned how demanding the course was, as well as the pitfalls of being irresponsible and lazy. However, others placed great blame on their 'insufficient' high school preparation and the lack of patience CHEM 120 (syllabus and instructor) allowed towards such preparation. Some simply reiterated what they did in lab each week with no additional insights.

Students enjoyed the opportunity to do hands-on investigations and work with lab partners, yet did not like the 'minds-on' demands of preparing for lab. Students generally did not enjoy the constant accountability required of them. Complaints generally related to safety requirements, deadlines for assignments, independent decision making, 'Pop' quizzes, and quality of lab reports.

The most striking reflections typically revolved around the issues of grades and locus of control. One 'D' student commented about lab report grades: *This will put my future in jeopardy, diminish my GPA, and setback my goals for this class.* Yet another 'D' student wrote: *In conclusion, despite my poor grades I feel I learned just as much as anyone else in class. I do not feel dumber than any other student or at a disadvantage. I only know that it was harder for me to understand all the theories and formulas and concepts that chemistry involves.* Others felt there was insufficient guidance to determine the 'right answers;' some directly attributed their grades to unreasonable or unfair expectations on the instructor's part. One student alluded that his own inability to know what he was doing should not be held against him or his course grade; if told specifically what to do in detail *prior* to lab activities, he would be able to do things successfully.

Two common recommendations were for a minimally satisfactory grade for the course, and challenges being kept to a minimum to ensure good grades. Some students went as far as recommending a grade of 'C' as reasonable for simply attending all class sessions. Some students lamented their perceived inability to earn a good grade without

appropriate instructor assistance throughout the course. Some students even suggested their lab report grades were a function of how detailed the instructor spelled out directions. Many expressed a need for special class sessions dedicated to giving directions for lab activities ahead of time versus reading a handout on their own. Very rarely did students directly attribute their grades to individual effort or performance; such factors were irrelevant, since students did precisely what was assumed expected.

There were students, however, who not only sensed genuine growth, but could substantiate it by recounting their errors of trying short-cuts and rushing through lab activities, writing lab reports, studying, and taking quizzes or tests. Not too surprising, most of these students earned grades of 'A' or 'B.' These students developed a consciousness of themselves, their strengths, and their weaknesses. Furthermore, these students directly attributed their success or failure to themselves, sometimes to a fault. These students were thankful for the demands of CHEM 120, and were among the most eager for CHEM 121 and the challenges ahead; some were specifically interested in taking the course with the "toughest" professor teaching the course. This perspective was further enhanced by these students earning the highest grades on their cumulative final exam, demonstrating their comprehensive growth.

Overall, of the 13 HCP freshmen in CHEM 120 sections #9 and 10, 1 earned an 'A,' 6 earned a 'B,' 1 earned a 'C,' 3 earned a 'D,' and 1 failed the course. The most negative reflections towards the course and instructor came from 'D' students; the most positive reflections came from 'B' students. Students earning higher grades tended to reflect a more internal locus of control than students earning lower grades; the better students looked more to internal influences for success.

A similar pattern was observed on course evaluations. The same complaints in reflective essays appeared on evaluations: lack of guidance, unreasonable demands, unfair expectations, consequences towards grades. Educators are potentially evaluated by students in terms of grades, not challenges or learning experiences. As much as this may reflect school cultures, it may also reflect the maturity of students.

Perhaps an interesting observation in this continuing study is the number of students who perceive themselves successful so far in CHEM 121, and consider their CHEM 120 experience a significant influence. Regardless of how they performed, most students (even one of the 'D' students) now consider the demands of CHEM 120 were ultimately appropriate for the academic expectations awaiting them. Some students even consider CHEM 121 "easy" because of the challenges experienced in CHEM 120.

There are some students, however, who find CHEM 121 very difficult; they attribute this to the lack of confidence given in CHEM 120. It is interesting to note that

this confidence was *given*, not *developed*. External locus of control remains significant; the teacher is the source of students' confidence, not the students themselves. This may be due to students considering the teacher the source of their success versus themselves.

However, one recurring theme seems to be a realization that the demands of their CHEM 120 instructor was indeed a manifestation of nurturing pedagogy; many have expressed dissatisfaction with the quality of instruction in CHEM 121. Although their grades may seem better with a different instructor, students are keenly aware that the classroom culture is less community oriented and more geared towards dispensal of content. Already students observe other faculty uninterested in seeking understanding during class time, much less addressing questions. In the traditional paradigm of dispensal, lecture time is indeed that -- lecturing, not discussing. Students painfully realize their new experiences are the norm, not the exception. Therefore, they condition themselves to this environment, and conform to the expectations of this impersonal learning culture.

Why are these observations so intriguing yet troubling? What are the underlying meanings? How do we address such perspectives within our classrooms? While students have high expectations of themselves academically, their intellectual expectations are quite low. While they want to be challenged and experience success, they have little desire to be challenged without a safety net. For all the efforts and resources DC&B faculty and HCP advisors provide these students, the students consider it insufficient. The number of students who experience relative success is more than those who do not;those experiencing superlative success (i.e., medical school) are still a small minority.

Our data is fairly inconclusive, yet, one general theme can be explored. Students are a product of their learning environment, and the internal socio-cognitive influences they carry are indeed formed and maintained by external influences. Students coming from a learning environment of neglect and low expectations will develop their own self-neglect and low expectations. Students coming to a learning environment of neglect and low expectations will maintain themselves accordingly. However, even if they came to a nurturing learning environment, that nurturing would need to continue for several semesters before students internalize any high expectations. Our universities do not consistently provide such environments.

By nurturing, we do not mean pandering or coddling; nurturing means to provide appropriate opportunities for growth and independence. Enculturing students to low expectations and minimal challenges only reinforces the notion that students are incapable of achieving success and making decisions on their own. We work in a culture

of helplessness, and perpetuate this helplessness; we propagate generations of dysfunctional college graduates to chastize.

However, the issue tends to reflect power and hierarchy. John Dewey, in both *Democracy and Education* (1916) and *Experience and Education* (1938), questions whether the practices of a learning environment stunt the growth of learners. A democratic culture ensures a degree of freedom. That freedom ensures a degree of social control and choices. The ability to control a situation and have choices empowers one to make decisions. A culture based on blind obedience and submissive deference only ensures an external locus of control and little empowerment. As a result, learners know their place, their limits, and their significance; needless to say, this is very stunting.

As students begin to express dissatisfaction with their current experiences, they resign themselves somehow to the notion that the status quo remains strong; the nurturing and demanding environment they encountered before is merely a past aberration. Students who complained how demanding learning expectations affected their GPAs now realize even less margin for error exists. No more 'Pop' quizzes, reflective essays, or multiple lab reports; the opportunities for assessment are drastically reduced and narrowed, enhancing the chances of failure when failure is expected. Students lacking the confidence to believe in their own ability to learn and succeed risk becoming self-fulfilling prophecies, as they are even more removed from the most-important resource, caring faculty. Despite step-by-step lab manuals and regurgitation-oriented tests, students lose their motivation to think critically; students are actually learning less and showing less for their academic grades.

Essentially, the learning culture of traditional science curricula and pedagogy dupe students into believing they learned significant amounts of material, empowered to achieve anything they set their minds to. This is unfortunately not the case. By duping students, the traditionalists have essentially found a way to minimize genuine learning and keep students at a lower level of understanding. Perhaps this is unwitting on the part of faculty; perhaps it is by design. We perpetually program students to think only to the tip of their noses, and disregard what lies beyond. We neglect exposing students to this extended territory, trivializing it and telling students it's beyond their ability to comprehend. Worse, we may even tell students such information will be experienced later in their education, only to eventually deny them of such experience anyway.

Ultimately, this paper addresses a program that seeks to empower students as individual and successful thinkers in a *depowering* culture. In a culture that promotes helplessness, we want students to help themselves and continuously look within themselves for inspiration and motivation. The culture of helplessness discourages this;

students are dictated artificial limits when they should know no limits at all. The culture of helplessness continues to enculture student dependency on the arbiters of knowledge, the gatekeepers of success, their very own professors. Dependent students limit the potential threat hierarchies of power existing within our schools apparently fear. The culture of helplessness beholdens students as indentured servants to a paradigm of learning hardly reflective of the learning we envision; one cannot be emancipated if freedom requires permission.

We do not propose solutions to a problem, since any problem within the dysfunctional context of schools is considerably complex. The dysfunction we identify and seek to rectify is hardly limited to African-Americans and Latino-Americans; the culture of helplessness is limitless, permeating to **all** students.

However, within the culture of helplessness, students of African and Latino heritage are acutely susceptible to dysfunctional obedience. They are least likely to come to universities with a sense of intellectual identity, self-confidence, self-reliance, or self-significance in the sciences. Brainwashed with the notion "they can't do it," HCP students come to the university unwilling to believe they **can** "do it," and they **can** "do it" by taking advantage of their most-valuable resource, themselves. HCP students **can** "do it" if they realize others will not "do it" for them; relying on the culture of helplessness essentially means nobody will "do it."

We cannot re-program HCP students to believe in themselves without providing continuous opportunities for self-reliance. This is different from opportunities for success. Many students experience artificial success; their attribution and obedience to the arbiters of knowledge reflects this. To become self-reliant is to develop a *consciousness of self*, an awareness that one can achieve independently and internalize that achievement. Although we strive for advanced cognitive development, we realize such development cannot take place without an epistemological development. Meaningful epistemologies need to come from within individuals, laying the foundation for future experiences, challenges, successes, and opportunities. We struggle to achieve this goal in the culture of helplessness, but continue nonetheless. On a relatively small scale, we struggle to build a counter-culture of empowerment. Size of scale notwithstanding, building the counter-counter is of great importance. The members within our counter-culture are of great importance. Someday, they will realize this, and transform the culture of helplessness into the culture of empowerment we envision for them.

During the phase of the closed society, the people are *submerged* in reality. As that society breaks open, they *emerge*. No longer *mere spectators*, they uncross their arms, renounce expectancy, and demand intervention. No longer satisfied to watch, they want to participate. This participation disturbs the privileged elite, who band together in self-defense. (Freire, 1973, pp. 13-14)

Assistencialism is an especially pernicious method of trying to vitiate popular participation in the historical process. In the first place, it contradicts [our] natural vocation as Subject in that it treats the recipient as a passive object, incapable of participating in the process of [one's] own recuperation; in the second place, it contradicts the process of "fundamental democratization." The greatest danger of assistencialism is the violence of its anti-dialogue, which by imposing silences and passivity denies [them] conditions likely to develop or to "open" their consciousness. For without an increasingly critical consciousness [they] are not able to integrate themselves into a transitional society, marked by intense change and contradictions. Assistencialism is thus both an effect and a cause of massification.

The important thing is to help [them] help themselves, to place them in consciously critical confrontation with their problems, to make them the agents of their own recuperation. In contrast, assistencialism robs [them] of a fundamental human necessity -- responsibility... Responsibility cannot be acquired intellectually, but only through experience. Assistencialism offers no responsibility, no opportunity to make decisions, but only gestures and attitudes which encourage passivity... this method cannot lead... to a democratic destination. (Freire, 1973, pp. 15-16)

REFERENCES

Atwater, M.M. (1996). Social Constructivism: Infusion into the Multicultural Science Education Research Agenda. *Journal of Research in Science Teaching ,33*, 821-837.

Atwater, M.M., Crockett, D., & Freeman, T. (1997). Journeys in Multiculturalism: A Continuing Saga. Presentation at the NARST Annual Meeting in Oak Brook, IL, March 21-24.

Babcock, G.T. (1996). More on Education. *Chemical and Engineering News ,74(40)*, 7.

Borg, W.R., & Gall, M.D. (1989). *Educational Research: An Introduction*. White Plains, NY: Longman.

Bruner, J. (1971). The Process of Education Revisited. *Phi Delta Kappan, 53*, 18-21.

Bruner, J., & Haste, H. (Ed.) (1987). *Making Sense: The Child's Construction of the World*. New York: Methuen.

Burke, B.A. (1997). Teaching Chemistry with Writing: More than Just the Facts. In M.W. Caprio (Ed.), *From Traditional Approaches Toward Innovation* (pp. 17-22). Washington: Society for College Science Teachers.

Chi, M.T.H., Bassok, M., Lewis, M.W., Reimann, P., & Glaser, R. (1989). Self-Explanations: How Students Study and use Examples in Learning to Solve Problems. *Cognitive Science, 13*, 145-182.

Clewell, B.C., & Ginorio, A.B. (1996). Examining Women's Progress in the Sciences from the Perspective of Diversity. In: C.S. Davis, A.B. Ginorio, C.S. Hollenshead, B.B. Lazarus, P.M. Rayman, & Associates (Ed.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering* (pp. 163-231). San Francisco: Josey-Bass.

Cochran-Smith, M. (1995). Uncertain Allies: Understanding the Boundaries of Race and Teaching. *Harvard Educational Review, 65*, 541-570.

Damarin, S.K. (1993). Schooling and Situated Knowledge: Travel or Tourism? *Educational Technology, 33(3)*, 27-32.

deJong, T., & Ferguson-Hessler, M.G.M. (1986). Cognitive Structures of Good and Poor Novice Problem Solvers in Physics. *Journal of Educational Psychology, 78*, 279-288.

Delpit, L.D. (1988). The Silenced Dialogue: Power and Pedagogy in Educating Other People's Children. *Harvard Educational Review, 58*, 280-298.

Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education*. New York: Macmillan.

Dewey, J. (1938). *Experience and Education*. New York: Macmillan.

BEST COPY AVAILABLE

Domin, D.S. (1997). The Transition from a Traditional to a Problem-Based Laboratory Curriculum. In M.W. Caprio (Ed.), *From Traditional Approaches Toward Innovation* (pp. 55-59). Washington: Society for College Science Teachers.

Driscoll, M.P. (1994). *Psychology of Learning for Instruction*. Boston: Allyn and Bacon.

Ferguson-Hessler, M.G.M., & deJong, T. (1990). Studying Physics Texts: Differences in Study Processes Between Good and Poor Performers. *Cognition and Instruction, 7*, 41-54.

Freire, P. (1970). *Pedagogy of the Oppressed*. New York: Continuum.

Freire, P. (1973). *Education for Critical Consciousness*. New York: Continuum.

Giroux, H.A. (1988). *Schooling and the Struggle for Public Life: Critical Pedagogy in the Modern Age*. Minneapolis, MN: University of Minnesota Press.

Giroux, H.A. (1992). Educational Visions: What are schools for and what should we be doing in the name of education? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 277-284). New York: Peter Lang.

Glazer, F.S. (1997). From Lecture to Discussion-Based Teaching. In M.W. Caprio (Ed.), *From Traditional Approaches Toward Innovation* (pp. 23-32). Washington: Society for College Science Teachers.

Greene, M. (1992). Educational Visions: What are schools for and what should we be doing in the name of education? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 285-293). New York: Peter Lang.

Greenfield, T.A. (1996). Gender, Ethnicity, Science Achievement, and Attitudes. *Journal of Research in Science Teaching, 33*, 901-933.

Hammersley, M. (1992). *What's Wrong with Ethnography?* London: Routledge.

Hobson, A. (1996a). Incorporating Scientific Methodology into Introductory Science Courses. *Journal of College Science Teaching, 25*, 313-317.

Hobson, A. (1996b). Teaching Quantum Theory in the Introductory Course. *Physics Teacher, 34*, 202-210.

Hoogstraten, C. (1996). Educating Nonspecialists. *Chemical and Engineering News ,74*(33), 66.

hooks, bell (1994). *Teaching to Transgress: Education as the Practice of Freedom*. London: Routledge.

Jonassen, D.H. (1993). Changes in Knowledge Structures from Building Semantic Net versus Production Rule Representations of Subject Content. *Journal of Computer-Based Instruction, 20*(4), 99-106.

BEST COPY AVAILABLE

Kahle, J.B. (1996). Opportunities and Obstacles: Science Education in the Schools. In: C.S. Davis, A.B. Ginorio, C.S. Hollenshead, B.B. Lazarus, P.M. Rayman, & Associates (Ed.), *The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering* (pp. 57-95). San Francisco: Josey-Bass.

Kincheloe, J.L. (1991). *Teachers as Researchers: Qualitative Inquiry as a path to Empowerment.* London: Falmer Press.

Kincheloe, J.L. (1992). Education Reform: What have been the effects of the attempts to improve education over the last decade? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 227-232). New York: Peter Lang.

Kincheloe, J.L. (1993). *Toward a Critical Politics of Teacher Thinking: Mapping the Postmodern.* Westport, CT: Bergin and Garvey.

Lawson, A.E. (1994). Research on the Acquisition of Science Knowledge: Epistemological Foundations of Cognition. In D.L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (pp. 131-176). New York: MacMillan.

Lewis, M. (1992). Power and Education: Who decides the forms schools have taken, and who should decide? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 41-50). New York: Peter Lang.

Macedo, D. (1994). *Literacies of Power: What Americans are not Allowed to Know.* Boulder, CO: Westview Press.

Maloney, D.P. (1994). Research on Problem Solving: Physics. In D.L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (pp. 327-354). New York: MacMillan.

McLaren, P. (1992). Education as a Political Issue: What's missing in the public conversation about education? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 249-262). New York: Peter Lang.

Perry, W.G. (1970). *Forms of Intellectual and Ethical Development in the College Years, a Scheme.* New York: Holt, Rinehart, and Winston.

Piaget, J. (1972). Intellectual Evolution from Adolescence to Adulthood. *Human Development, 15,* 1-12.

Pinar, W.F. (1992). The Curriculum: What are the basics and what are we teaching them? In J.L. Kincheloe & S.R. Steinberg (Ed.), *Thirteen Questions: Reframing Education's Conversation* (pp. 31-38). New York: Peter Lang.

Popkewitz, T.S. (1998). A Changing Terrain of Knowledge and Power: A Social Epistemology of Educational Research. *Educational Researcher, 26*(9), 18-29.

BEST COPY AVAILABLE

Pushkin, D.B. (1994a). Who Says Minorities Don't Belong in Science and Engineering? Presentation at the July 11-15 Minority Teachers for the 21st Century conference at Penn State University.

Pushkin, D.B. (1994b). Should the APS get Involved with Education? Yes, but Look Before you Leap! *American Journal of Physics*, *62*, 696.

Pushkin, D.B. (1995). *The Influence of a Computer-Interfaced Calorimetry Demonstration on General Physics Students' Conceptual Views of Entropy and Their Metaphoric Explanations of the Second Law of Thermodynamics*. Copyrighted Dissertation, Pennsylvania State University.

Pushkin, D.B. (1996). More on Education. *Chemical and Engineering News*, *74(40)*, 7.

Pushkin, D.B. (1997a). The Stereotypes of Physics: Are We Alienating Ourselves as Well as Others? Invited presentation at the AAPT summermeetingin Denver, CO, August 11-16.

Pushkin, D.B. (1997b). Perceptions of Women in Physics: Is There Something Wrong With This Picture?! Presentation given at the AAPT winter meetingin Phoenix, AZ, January 4-9.

Pushkin, D.B. (1997c). Teaching vs. Research. *Physics and Society*, *26(1)*, 2.

Pushkin, D.B. (1997d). The Philosophical Basis of Social Constructivism for Our Pedagogy. Presentation at the AAPT summermeetingin Denver, CO, August 11-16.

Pushkin, D.B. (1997e). Where do Ideas from Students come from? Applying Constructivism and Textbook Problems to the Laboratory Experience. *Journal of College Science Teaching*, *26*, 238-242.

Pushkin, D.B. (1997f). Promoting Situated Cognition at the Introductory Level: The Consequence of Contextual Differentiation in Problem Solving. *Journal of Physics Education Research*, submitted for publication.

Pushkin, D.B. (1998a). Perceptions of Women in Physics: Is There Something Wrong With This Picture?! *Association of Women in Science Magazine*, *27(1)*, 11-13.

Pushkin, D.B. (1998b). Novice, Conceptual, and Algorithmic Learners. *Journal of Chemical Education*, in press.

Scheurich, J.J., & Young, M.D. (1997). Coloring Epistemologies: Are Our Research Epistemologies Racially Biased? *Educational Researcher*, *26(4)*, 4-16.

Schoenfeld, A.H. (1978). Can Heuristics be Taught? In J. Lochhead & J.J. Clement (Ed.), *Cognitive Process Instruction* (pp. 315-338). Philadelphia: Franklin Institute Press.

Shulman, L.S. (1986). Those who Understand: Knowledge Growth in Teaching. *Educational Researcher*, *15*, 4-14.

BEST COPY AVAILABLE

Shulman, L.S. (1988). Disciplines of Inquiry in Education: An Overview. In R.M. Jaeger (Ed.), *Complementary Methods For Research in Education* (pp. 3-17). Washington: American Educational Research Association.

Simmers-Wolpow, R. (1995). *Trauma,Literacy and the Pedagogy of Hope.* Copyrighted Dissertation, Pennsylvania State University.

Thomas, K. (1990). *Gender and Subject in Higher Education.* Buckingham, UK: Open University Press.

Walker, D., & Lambert, L. (1995). Learning and Leading Theory: A Century in the Making. In: L. Lambert, D. Walker, D.P. Zimmerman, J.E. Cooper, M.D. Lambert, M.E. Gardner, & P.J. Ford-Slack (Ed.), *The Constructivist Leader* (pp. 1-27). New York: Teachers College Press.

Wennerås, C., & Wold, A. (1997). Nepotism and Sexism in Peer-Review. *Nature,387,* 341-343.

Wiley, R. (1991). *Why Black People Tend to Shout.* New York: Penguin Books.

Windschitl, M., & Andre, T. (1998). Using Computer Simulations to Enhance Conceptual Change: The Roles of Constructivist Instruction and Student Epistemological Beliefs. *Journal of Research in Science Teaching, 35,* 145-160.